

# Endovascular Treatment of Intracranial Aneurysms

## "An Update"

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The endovascular treatment of intracranial aneurysms has evolved over the last decade from a timid alternative to surgical clipping to a very well accepted universally expanding form of therapy. Recent randomized clinical trials (ISAT) have legitimized the advantages of the endovascular treatment over surgery.

The mainstay of the endovascular treatment is the electrically detached platinum coil introduced in the early nineties by Guido Guglielmi (GDC). The GDC influenced favorably the acceptance of endovascular treatment of aneurysms due primarily to its efficacy, ease of use and reliability. More and more physicians from different disciplines have learned the basic techniques of endovascular treatment and are now practicing them. The associated mortality and morbidity continue to improve steadily.

Several improvements have been made to the GDC which have resulted in a better safety record and better long term anatomical results. These improvements include: a smaller gauge primary wire, a "soft" and "ultrasoft" version, a faster and more reliable detachment mechanism, a stretch-resistant coil, etc.

However, and despite these improvements, there remains a major drawback to the use of GDC which is the poor long term anatomical results, i.e. high recanalization rate, in large and giant aneurysms and in aneurysms with a wide

neck. Whereas the long term anatomical results are good in small aneurysms with small neck, large aneurysms with wide neck have an unacceptably high rate of recanalization of at least 20 to 30%.

Several new technologies have emerged for the purpose of improving the efficacy of bare platinum coils. These include:

- 1 - New complex-shaped coils that conform better to complex-shaped or large aneurysms and therefore produce a better obliteration rate, particularly in the long term.

- 2 - Faster detachment mechanism which is more reliable than the original electrolytic detachment.

- 3 - Adding an expansile material to the platinum coil such as hydrogel to improve the fill-factor of the aneurysm and therefore the long term obliteration rate.

- 4 - Modifying the surface of the platinum coils to induce more fibrous tissue within the aneurysm and therefore accelerate the healing process. The surface modifiers that have been used so far include a polyglycolic acid (PGLA) polymer and a radioactive isotope ( $P^{32}$ ).

In addition to modifying platinum coils, other devices have been introduced as adjuncts to coiling. These include:

- 1 - The Trispan® neck bridge device designed primarily to aid in the packing of terminal and

bifurcation wide-neck aneurysms with platinum coils.

2 - Low-profile balloon-expandable metallic stents designed primarily for the reconstruction of the parent artery in large and wide-neck aneurysms.

3 - Flexible and low-profile self expanding stents made of Nitinol and designed for the reconstruction of the parent artery.

4 - Flexible covered stents designed to exclude large and giant aneurysms from the Parent Circulation.

Other embolic agents have also been developed either as replacement or adjunct to platinum coils in the endovascular treatment of aneurysms. These include:

1 - Ethyl Vinyl Alcohol (EVOH) polymer dissolved in Dimethyl Sulfoxide (DMSO) commercialized under the trade name of Onyx®.

2 - Derivatives of Cyanoacrylate such as Neuracryl®.

### Improved Detachment Mechanism

At least three new detachment mechanisms have been introduced over the last few years and have contributed towards faster and safer procedures.

The electrolytic detachment had become somewhat unreliable and time-consuming particularly in large aneurysms that require a large number of platinum coils. New hydraulic detachment mechanisms introduced by Cordis Neurovascular, Inc. and Microvention, Inc. are reliable, safe and simple. More important, the hydraulic detachment is almost instantaneous and is independent from the number of coils used to obliterate a particular aneurysm. Another detachment mechanism introduced by Micrus, Inc. uses mild heat to release the coil and also offers the advantage of almost instantaneous detachment.

### Complex-shape Coils

In addition to the pre-existing 3 dimensional coils, other more complex shaped coils are now being used for better packing and initial framing of wide neck and large aneurysms. These new generation complex coils seem to offer an advantage over helical coils in densely packing the aneurysm and therefore in obtaining better long-term anatomical results.

### Surface-modified Coils

New technology has become available to improve the thrombogenicity and the healing effect of bare platinum coils on the wall of the aneurysm. The Matrix® coil consists of a platinum coil covered with a layer of the PGLA polymer which is intended to reduce the amount of resorbable thrombus inside the embolised aneurysm and replace it fibrous tissue and smooth muscle cells.

The larger amount of fibrous tissue and smooth muscle cells help improve the healing phenomenon and leads to more scar tissue around the aneurysm neck. A post-market study (ACTIVE study) of 100 patients treated with the Matrix coil has been concluded in the USA and Europe with the purpose of assessing the safety and efficacy of this surface-modified coil. The preliminary results indicate a beneficial effect of the adding of the PGLA polymer to the platinum in term of aneurysm obliteration. Improvements are being made to the matrix coil to reduce the rather high friction encountered with its use.

Hydrogel is another material currently being used as an additive to platinum in the endovascular treatment of aneurysms. The Hydrocoil® consists of a platinum coil covered with a layer of expansile hydrogel. The coil is introduced in the aneurysm not hydrated. Once inside the aneurysm and within several minutes, the hydrogel material imbibes water from the blood, becomes hydrated and expands according to a predetermined expansion ratio.

The expanded hydrogel becomes a filling material that obliterates the obligatory dead space usually contained in between the platinum coils and improves the chances of completely obliterating the aneurysm. The angiographic results of the early clinical use of the Hydrocoil are pending.

Another modification being used to improve the healing effect of platinum coils is the addition of radioactive P<sup>32</sup>. The radioisotope emits beta irradiation which is intended to inhibit recanalization and to promote healing of the aneurysm neck. The early clinical experience with radioactive coils is encouraging and appears to be safe both to the patient and operator. However, additional experience and data is needed to determine whether or not the addition of radioactive material to platinum coils is beneficial.

### Coil-retention Devices

Modifying the surface of platinum coils to improve the healing response can produce a better long term anatomical result. However, other devices are needed to aid in the packing of wide neck aneurysms and in preventing the coils from prolapsing in the lumen of the parent artery.

These coil-retention devices act as a temporary or permanent barrier to help retain the coils or other embolic materials inside the aneurysm. One such device, Trispan® has been used for the treatment of wide-neck bifurcation aneurysms with mixed anatomical results. Although such a device helps in retaining the coils, it does not alter significantly the undesirable high rate of recanalization.

Other coil-retention devices currently used in the endovascular treatment of aneurysms include metallic stents. A variety of balloon-expandable stainless steel stents have been used in the intracranial circulation in an effort to reconstruct a dysplastic parent artery at the level of the aneurysm neck.

These stents are very effective and have significantly improved the endovascular treatment of complex and large aneurysms. They are usually combined with platinum coils and/or with liquid polymer as embolic material. Although effective, balloon-expanded metallic stents are very stiff and difficult to navigate particularly in tortuous vasculature. The need for more flexible and easy to navigate stents has led to the development of low profile and very flexible self expanding stents made out of Nitinol. One such stent, the Neuroform® is preloaded inside a flexible microcatheter measuring 3 french in its outside diameter. It is introduced in the intracranial circulation and positioned across the neck of the aneurysm over an exchange guidewire measuring 0.014 inch in diameter.

The early clinical experience with this self expanding stent is encouraging and has permitted the endovascular treatment of difficult and complex aneurysms.

Another promising treatment for giant aneurysms is the use of covered stents commonly used for extracranial applications. These stents reconstruct the parent artery, exclude the aneurysm from the parent circulation and do not require the use of a filling material or embolic agent. The major difficulty in using cov-

ered stents is their navigation in the intracranial circulation, particularly around the bends of the carotid siphon. Also, they cannot be used in an arterial segment with dependents branches and are therefore limited to arterial segments located proximal to the origin of the anterior choroidal artery.

### Liquid Embolic Material

Is another promising device for the endovascular obliteration of aneurysms, particularly large aneurysms with wide neck. Compared with platinum coils, liquid embolic material conforms better to the aneurysm wall, allows for less or no dead space and provides a better reconstruction of the neck.

The technique of injecting liquid polymer in intracranial aneurysms is difficult and cumbersome. It requires the use of an occlusion balloon to create a seal at the neck of the aneurysm during the injection of the polymer. A poor seal around the neck can lead to undesirable leak of the embolic material in the parent artery and ultimately to thrombo-embolic and occlusive complications.

The existing liquid polymer lacks any adhesive property and has shown an unpredictable recanalization rate. The major advantage of liquid polymer is that it allows for the treatment of complex aneurysms with unidentifiable neck which would be difficult to obliterate with platinum coils.

Liquid polymer can be combined with metallic stents for the treatment of large and complex aneurysms. The stent is used to reconstruct the parent artery and the polymer obliterates the lumen of the aneurysm. This combined technique has been used successfully in numerous giant aneurysms which would have otherwise required sacrifice of the parent artery.

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